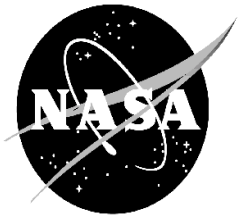

Office of Biology and Physical Research
Washington, DC 20024

Space Life Sciences

Ground Facilities Information Package

2003

A Companion Document
to
NASA Solicitations
in
Space Life Sciences

Space Life Sciences
Ground Facilities Information Package
2003

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Introduction

This supplement is a companion to research solicitations released in 2003 by the National Aeronautics and Space Administration (NASA). The various sections of this supplement provide a common basis for proposal preparation and submission by any eligible scientist.

Interested persons who do not have a copy of the appropriate research solicitation should contact

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Special Ground Research Facilities in the United States

This document provides descriptions of special research facilities currently available for use by the scientific community. These facilities are available to investigators for ground research at sites specified in the description. **Applicants must contact the person(s) identified at the end of each facility's description for additional scientific and technical information.** Proposals which request use of ground facilities will be reviewed to ascertain scientific feasibility and rationale for facility use prior to development of facility support for such studies. Investigators wishing to use the NASA Ames Research Center (ARC) Acceleration Facilities must submit the Facilities Questionnaire (http://lifesci.arc.nasa.gov/CGBR/questionnaire.html) minimally one month prior to submittal of their grant proposal and prior to calling the Facilities Utilization Office to assure adequate assessment of feasibility of performing experiment activities at ARC. Proposals that request use of ground facilities will be reviewed to ascertain scientific feasibility and rationale for facility use prior to development of facility support for such studies. Applicants are cautioned that the cost of using these facilities, where applicable, and the cost of traveling to and from the facilities must be included in any proposal requiring them. Facility use costs **must** be negotiated and approved by the listed contact person **prior** to proposal submission.

Table 1. Cross-Reference Table

1. The Vestibular Research Facility (VRF)

The VRF at the NASA Ames Research Center (ARC) provides unique equipment designed to study the physiological responses to angular and linear accelerations over a broad range of frequencies including those of natural head movement. Specific space related and non-space related science question may be addressed. Questions that address the interaction of the vestibular system with the visual and proprioceptive sensory systems may also be examined. The VRF houses the following equipment:

- Multi-axis Centrifuge
- 30-Foot Linear Sled
- Programmable Linear Sled

Information on the VRF is also available online at http://lifesci.arc.nasa.gov/CGBR/CGBR.html For further information, contact Tianna Shaw, FUO Manager at the NASA Ames Research Center (telephone: 650-604-6496, email: Tianna.L.Shaw@nasa.gov).

1.1 The VRF Multi-axis Centrifuge

The VRF Multi-axis Centrifuge allows an investigator to examine physiological responses to angular or combined linear and angular accelerations. Up to 2 g linear (centrifugal) acceleration can be applied to a gimbaled Specimen Test Container (STC) whose center is at a 1.0 m radius from the centrifuge's axis of rotation. Gimbal motors allow an experimenter to apply DC to 5 Hz angular motions (up to 500º/sec velocity and 500º/sec^2 acceleration) to the STC and its 54-pound payload during centrifugation. There are four axes of motion: a main spin axis, outer and inner high perform spin axes, and an inner positioning axis. Fifteen electrically isolated slip-ring assemblies allow the recording of multiple channels of electrophysiological data continuously during centrifugation. This centrifuge accommodates small primates and rodents or smaller animal or plant specimens.

1.2 The VRF 30-Foot Linear Sled

The VRF 30-Foot Linear Sled uses air bearings to produce silent, frictionless linear motion for studies of human perception of linear acceleration without confounding vestibular cues with somatosensory cues. The long track enables lower stimulus frequencies (periodic motion from 0.25 Hz to 5.0 Hz at 0.5 g peak), and noise-free periods of constant linear velocity (trapezoidal profiles with acceleration and deceleration of 1.0 g, and 100 cm/sec constant velocities). It consists of an experimental platform floating on air bearings on a granite surface. A chair is mounted on the platform to accommodate human subjects or a specimen container for non-human subjects.

1.3 Programmable Linear Sled (PLS)

The PLS uses air-bearings and linear motor technology to study vestibular system responses in small primates, rodents, or smaller animal specimens. This device allows studies of electrophysiological, reflex, or behavioral responses during precisely controlled linear oscillations (1.0 Hz to 5.0 Hz, $\pm$1 g peak acceleration) parallel or perpendicular to Earth gravity (i.e., horizontally or vertically). The PLS supports short-term studies of biological responses to linear acceleration.

2. Human-Rated Hypergravity Facilities

The NASA Ames Research Center has two hypergravity facilities that enable psychophysical and physiological research on humans and other species. They are

- the 20-G Human-Rated Centrifuge
- the Human Powered Centrifuge

Information on the Human-Rated Hypergravity Facilities is also available online at http://lifesci.arc.nasa.gov/CGBR/CGBR.html. For further information, contact Tianna Shaw, FUO Manager at the NASA Ames Research Center (telephone: 650-604-6496, email: Tianna.L.Shaw@nasa.gov).

2.1 The 20-G Human-Rated Centrifuge

The 20-G Centrifuge, NASA's only centrifuge currently human-rated to 12.5 g, delivers accelerations of 1 g/sec to 12 g and 0.5 g/sec from 12 g to 20 g under either manual or computer control. It is frequently used to simulate Space Shuttle launch and landing profiles for a variety of payloads. The centrifuge has three enclosed cabs, each with a 16,000 g-pound payload capacity. Cab A, at a 29-ft radius, contains a modified jet fighter seat for psychophysical or physiological tests. Cab B, located at the other end of the rotating arm, is an adaptable 6' by 6' room that accommodates a variety of payloads including human to A third cab, located near the center of rotation, can be used as a near-center control for angular acceleration. Hypergravity exposures for periods of minutes to hours are possible.

2.2 The Human Powered Centrifuge

The Human Powered Centrifuge is a 6.25-ft radius centrifuge. A stationary bicycle beside the centrifuge or a recumbent bicycle onboard offers the option of subject-generated operation. The centrifuge may be operated from minutes to hours, allowing human-generated gravitational forces for a payload of up to 500 pounds, without or with exercise. Human subjects have been found to be capable of generating up to 5 g's of acceleration, reaching maximum rotation speeds of 50 rpm. Electronic equipment for monitoring physiological parameters, such as cardiovascular function, temperature, oxygen consumption, and other basic data, may be mounted onboard. Instrumentation-quality slip rings are available to transfer signals off-board for real-time monitoring and data recording.

3. Parabolic Flights: The KC-135 "Zero-G" Aircraft

This aircraft, a specially modified version of a Boeing 707, can generate 20- to 30-second periods of microgravity and various levels and periods of hypergravity. This platform can be used to test and validate experimental equipment and new devices to ensure that they will operate properly in varying gravitational fields. Furthermore, since multiple parabolas can be flown, it is also possible to conduct experimental studies.

For further information, contact Todd Schlegel, Ph.D., at the NASA Johnson Space Center (telephone: 281-483-9643).

4. Non-Human Hypergravity Facilities

The NASA Ames Research Center has a suite of hypergravity facilities capable of supporting studies using non-human subjects and human and/or non-human tissues in addition to those listed above. These facilities include:

- 24-Foot Diameter Centrifuge
- International Space Station Test-Bed Centrifuge
- Low Vibration Rotational Device

Information on the Non-Human Hypergravity Facilities is also available online at http://lifesci.arc.nasa.gov/CGBR/CGBR.html. For further information, contact Tianna Shaw, FUO Manager at the NASA Ames Research Center (telephone: 650-604-6496, email: Tianna.L.Shaw@nasa.gov).

4.1 The 24-Foot Diameter Centrifuge

The 24-Foot Diameter Centrifuge is designed to create hypergravity for small animal (such as rats, guinea pigs, rabbits, or primates) and plant research. The centrifuge has 10 radial arms and carries up to 20 large, opaque, ventilated enclosures for holding animals and equipment. These enclosures can be located at different radii (variable from 4 ft to 12 ft at 6-inch intervals) to produce gravitational forces of up to three times Earth gravity on the floor of the enclosure. Three additional, smaller enclosures are available near the axis of rotation of the centrifuge, and eight stationary enclosures are available within the centrifuge rotunda to provide appropriate rotation and vivarium controls. Slip rings provide in-cage video monitoring and instrumentation capability. Hypergravity exposures are chronic (from days to months) with two half-hour stops per week for feeding and change of bedding.

4.2 The International Space Station Test-Bed Centrifuge (ISSTBC)

The ISSTBC accommodates International Space Station (ISS) habitats, and will be used for ISS ground control in the coming years. The ISSTBC can accommodate much of the Spacelab, SpaceHab, and shuttle Middeck compatible hardware that has flown previously. The maximum acceleration rate is 4.0 g. A maximum of four ISS habitats, each up to 250 lbs, can be placed on-board with ISS compatible interfaces for coolant, video and data. Non-ISS habitats, 18.5” wide x 25” deep x 24” high, can also be used. Environmental room temperature controls are matched to the ISS environment. The onset rate of the ISSTBC is matched to the ISS centrifuge, and is programmable for periods between 6.5 minutes to an hour.

4.3 The Low Vibration Rotational Device (LVRD)

The LVRD is a single-arm centrifuge with a 10-ft radius. It has a swing frame that can be positioned at various distances from the hub. Hypergravity levels up to 6 g can be provided. Hydrostatic bearings provide for precise angular with minimal vibration. Instrumentation-quality slip rings are available for off-board monitoring of experiment data.

The LVRD may be configured with an onboard carbon dioxide (CO_2) incubator to study the effect of short- or long-duration hypergravity exposure on cultured cells. This configuration is referred to as the Hypergravity Facility for Cell Culture (HyFaCC). Temperature, % CO_2, relative humidity, and g level data are transferred off-board through the slip ring assembly. The HyFaCC accommodates cell culture dishes of any type, but sealed vessels with vented caps are recommended for sterility. Additional equipment such as peristaltic pumps or automated cell culture devices may be accommodated. Studies up to 3-weeks duration may be run on the centrifuge. Long-duration studies will require stopping the centrifuge every 2 to 3 days for media replenishment unless a system to automatically replenish media is provided.

5. Ground-Based Radiation Accelerator Facilities

NASA has signed Memoranda of Agreement (MOA) with two ground-based laboratories where energetic beams of protons and high-energy heavy ions are available; in particular, proton beams at the **Loma Linda University Medical Center** (protons with energies between 70 MeV and 250 MeV), and the NASA Space Radiation Laboratory (NSRL) and Alternating Gradient Synchrotron (AGS) at **Brookhaven National Laboratory** (beams of protons heavy nuclei).). The NSRL devlivers beams with energies from about 50 to 2000 MeV/u and the AGS beams with energies from about 600 to 10,000 MeV/u. Delivery of beam time at the Brookhaven facility are directly funded by a contract between NASA and Brookhaven, and similar arrangements are intended for use of the beam time at Loma Linda University Medical Center.

5.1 Brookhaven National Laboratory

The NSRL was developed by DOE for NASA as a dedicated facility for space radiation radiobiology and shielding research utilizing the existing infrastructure at BNL. The AGS machine is a U.S. Department of Energy (DOE) facility that is funded by the DOE primarily for research in high-energy particle and nuclear physics. Use of the Brookhaven facilities (NSRL or AGS) requires a separate proposal, which is reviewed by a laboratory-appointed panel and is scheduled in accordance with available beam time and other laboratory resources. Once experiments are approved, they are required to satisfy the normal process of preparation for running at the AGS, which includes familiarization with AGS rules and policies (safety being the paramount consideration among these), and registration with the laboratory as a guest scientist.

User facilities have been developed at Brookhaven for radiation biology research, including cell cultures and small animals. These include at the NSRL the experimental building containing animal and cell biology laboratories, or the biological experiment station at the AGS. Dedicated laboratory space and animal facilities for NASA funded investigators are maintained in the Brookhaven Medical Department. A 10-ft long optical bench for sample exposures is available in the caves of both the NSRL or AGS, as well as beam handling, sample changing, and dosimetry instrumentation. The NSRL experimental building includes several laminar flow hoods, freezers, and incubators, and separate air handling systems for animal and cell culture experiments. At the AGS, the biological experiment station contains one area for cell culture equipped with a laminar flow hood and incubator, one short-term animal holding facility, and one area for physics/run-control use. In addition, laboratory space and access to animal facilities

accredited by the Association for Assessment and Accreditation of Laboratory Animal Care are available in the Medical Department, subject to standard use charges. Brookhaven also has on-site housing accommodation for users (dormitory and apartment-style units).

A large number of ion species and energies are available at the NSRL or AGS. Typical ion sources include p, C, O, Si, Ti, Fe, and Au. Normally, circular beam spots are provided, with diameters up to 10 cm, and center-to-edge uniformity between 10% and 20% (depending on dose rate — high dose rate beams are less uniform than low-dose rate beams). Dose rates have been measured up to 11 Gy/min. Investigators currently funded by the NASA program participate in research using these beams, and coordination of beam use with these investigators and institutions is actively encouraged. In particular, a physics and dosimetry group is available for investigators requiring their assistance.

For further information regarding Brookhaven National Laboratory, contact Dr. Marcelo Vazquez (e-mail: vazquez@bnl.gov), Dr. Betsy Sutherland (e-mail: betsy@image.bio.bnl.gov), or Dr. Phil Pile (e-mail: pile@bnldag.ags.bnl.gov). The address is Brookhaven National Laboratory, PO Box 5000, Upton, NY 11973-5000. Information about this facility is also available at http://bnlstb.bio.bnl.gov/biodocs/nasa/nasa_ags.htmlx.

5.2 Loma Linda University

Loma Linda University operates a facility for therapy of cancer and other diseases using accelerated protons from a synchrotron, which is located within the medical center. Associated with the synchrotron are treatment rooms and all clinical services relevant to radiation therapy. Also associated with the synchrotron are an experimental area ("research room"), which can receive a proton beam, and an adjacent staging laboratory from which the accelerator can be operated and experiments may be configured prior to irradiation. Close to the accelerators is the new Chan Shun Pavilion, a wing of a research building whose first floor has been designated for a radiobiology research program with capabilities for modern cellular, molecular, and *in vivo* biology studies. Included in this structure is a laboratory dedicated for the use of visiting scientists whose research requires access to proton beams.

The basic beam line was designed to bring protons from 40 MeV to 250 MeV to the research room for experimental work while not interfering with patient treatments. The beam line will provide for flexible delivery of proton beams at doses, dose rates, energies, field sizes, and field uniformities that are adequate for many biology, physics, and materials science experiments. A Co-60 irradiator has been installed to provide gamma rays for control experiments.

For further information the Loma Linda University Medical Center, contact Dr. Gregory A. Nelson (telephone: 909-478-8366; e-mail: gnelson@lluci.llu.edu), Director, Radiobiology Program, Loma Linda University Cancer Institute, 11360 Mt. View Avenue, Hartford Bldg, Ste. B, Loma Linda, CA 92354. A description of the facilities at Loma Linda University Medical Center is available at http://www.llu.edu/proton/patient/overview/hightech.html.

6. Space Human Factors Facilities

The Graphics Research and Analysis Facility (GRAF), Anthropometry and Biomechanics Facility (ABF), and Usability Testing and Analysis Facility (UTAF) are managed by the Habitability and Human Factors Office at the Johnson Space Center. For further information, please contact Thomas Rathjen, M.S., at the NASA Johnson Space Center (telephone: 281-483-3651).

6.1 Graphics Research and Analysis Facility (GRAF)

The GRAF has systems for computer modeling of humans and environments. It provides anthropometric, kinematic, and visibility analyses of humans working in 1g, 0g, or partial g. GRAF has access to strength and size databases and a physically-based system for computer modeling illumination for camera/eye vision with the ability to empirically collect luminance and illuminance data. It also has a large collection of models of the Shuttle, Spacelab, Spacehab, and ISS modules in which to perform this integrated analysis of humans working in space both EVA and IVA.

6.2 Anthropometry and Biomechanics Facility (ABF)

The ABF collects and analyzes human strength, force, and motion data in a laboratory environment and in field settings such as the Neutral Buoyancy Laboratory (NBL), KC-135 0 g aircraft, and the Precision Air Bearing Floor (PABF). Equipment includes Lido dynamometers, Ariel Motion Analysis Systems, the Multipurpose Multiaxial Isokinetic Dynamometer (MMID), and waterproofed and KC-135-qualified force plates. The ABF personnel are experienced in collecting data from suited and unsuited subjects.

6.3 Usability Testing and Analysis Facility

The Usability Testing and Analysis Facility performs evaluations of crew interfaces for work areas and equipment, such as computer displays and controls, workstation systems, and other types of crew interfaces, from a cognitive and ergonomic perspective. Equipment includes multi-view video camera systems, separate subject and investigator observation rooms, video analysis tools, and task analysis software.

7. Biocomputational Modeling Facility: Center for Bioinformatics

The NASA Ames Research Center (ARC) for Bioinformatics is dedicated to the development and application of advanced visualization, computation and simulation technologies to support life science research. Equipment, software, and personnel capabilities allow support to the following four types of work:

1. 3-D Reconstruction (data from microscopic serial sections to multimedia medical scans)
2. Scientific Visualization and Modeling (diverse applications from structure and function of vestibular system, including genetic constructs, to astrobiology research)

3. Virtual Collaborative Environment Technologies (multicast collaborative interactions for scientific, educational, professional training, and medical applications)
4. Neurotechnology (from biological neuronal circuits and systems to chips, processors and computer architectures).

For further information, please contact Richard Boyle, Ph.D., at the NASA Ames Research Center (telephone: 650-604-1099, email: rboyle@mail.arc.nasa.gov)